

Variations in Glove Integrity and Chemical Resistance between Classes of Disposable Nitrile Gloves

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Introduction

Despite ongoing chemical protective clothing (CPC) availability, research, and testing efforts, about 2.9 million workers suffer from allergic and irritant dermatitis each year, with dermatitis accounting for 15–20% of all reported occupational diseases. (1) The National Institute for Occupational Safety and Health (NIOSH) has recognized CPC and exposure control technologies as research priorities in addressing this issue. (2,3) NIOSH has also identified the need for the development of whole garment tests for the performance of protective clothing used by first responders. (4)

One critical gap in the current knowledge is the protection afforded by protective clothing under worker-use conditions. (3) In addition, workplace protection factors, hygienic practices, and certifications have been established for respiratory equipment, but not for CPC. (4)

As an example, up to a 100-fold increase in field exposures through gloves relative to laboratory-based permeation data have been reported. ⁽¹⁾ Recent studies have identified whole-glove movement as accounting from some of this variation. ⁽²⁾ Additional studies have indicated that polymer content can account for a significant portion of the variation. ⁽³⁾ More research is needed to assess the influence of glove composition and whole-glove movement and on:

1. glove integrity (e.g. presence of holes); and
2. molecular permeation of chemicals through gloves.

Significance

Workplace protection factors and certifications have been developed and established for respiratory protection devices, but not for CPC. (6) Determination of those factors affecting whole-glove performance under work-use conditions will help in the development of improved materials performance and possible certification of disposable gloves. This would improve the protection provided to workers using disposable gloves as a barrier against chemical, physical, and biological hazards.

Methods

The main stages of the study were:

1. Select nitrile glove types and brands to represent different classes/formulations

- Cleanroom gloves with lower amounts of fillers
- Low modulus gloves with added fillers
- General-duty gloves with no special designation
- Medical-grade gloves

2. Conduct water leak testing under conditions of whole-glove movement versus no-movement
3. Conduct whole-glove permeation testing under conditions of simulated movement versus no-movement
4. Evaluate glove performance between the different classes of gloves

Water Leak Test

A modified water-leak test (Figure 1) was used in this study. Stretching in the cuff region was restricted using a 3-inch long coupling between the glove and adjoining water column. In addition, the water leak test was standardized to detect a small 30-gauge hole in various regions of the glove. The water volumes ranged between 1 to 2 liters.



Figure 1.
Modified Water
Leak Test

Permeation Testing

A previously designed test system (Figure 2) was used to measure chemical permeation under simulated whole-glove movement.

The gloves were inflated using a pressure of 0.10 $\pm$ 0.02 inches of water. Inflation and deflation of the glove was controlled using an available pneumatic controller.

Permeation testing was conducted using ethanol. Continuous monitoring was conducted using a photoionization detector in a closed-loop.

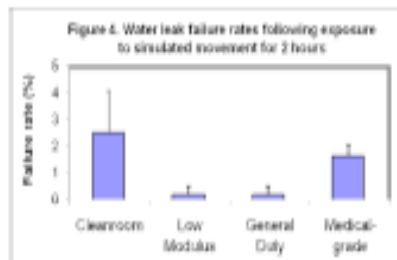


Figure 2. Whole-Glove Movement Permission Chamber

Results

Glove Integrity

Preliminary results with a 2-hour simulated exposure to movement indicated variations in glove integrity (Figure 4). On average, the cleanroom gloves had higher failure rates (2.6 $\pm$ 3.0%) and the low-modulus and general duty the lowest (0.3 $\pm$ 0.6% each). The medical grade failure rates were 1.7 $\pm$ 0.7%. Movement did not significantly affect glove integrity ($p \geq 0.05$).

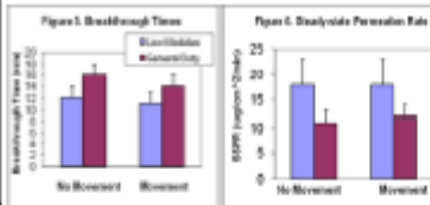


Chemical Resistance

Chemical permeation data were not complete for the cleanroom and medical-grade gloves.

In general, the low-modulus gloves were less affected by movement than the general duty gloves (Figures 5 and 6). However, the general duty gloves provided greater overall chemical resistance (Table 1 below) with longer breakthrough times (BT) and lower steady-state permeation rates (SSPR).

Glucose type	Breakthrough Time (min)		Steady-State Fermentation Rate ($\mu\text{g}/\text{m}^2/\text{min}$)	
	No movement	Movement	No movement	Movement
Low Molecular Weight Dextran	12 $\pm$ 4	11 $\pm$ 4	18 $\pm$ 9	18 $\pm$ 9
Control Data	16 $\pm$ 3	16 $\pm$ 3	11 $\pm$ 3	12 $\pm$ 4



Conclusions

The conclusions provided here are preliminary and pending completion of the glove testing, as well as other measurements.

There were variations in integrity between the different glove types, which may be due to the absence of plasticizers/fillers.

Simulated whole-glove movement did not have a significant effect on glove integrity.

Permeation of low modulus formulations was less affected by movement, which may be due to plasticizers/oils used to reduce modulus, plus reduced thickness.

General duty gloves provided slightly higher chemical resistance, which may be due to glove thickness differences.

Ongoing Research

The results presented here are part of a 2-year grant aimed at evaluating the role of glove composition and properties on whole-glove integrity and chemical resistance. Additional factors:

- Acrylonitrile content
- Polymer content (e.g. plasticizers and inorganic fillers)
- Polymer uniformity
- Tensile strength

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Acknowledgments

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